Cost-Effectiveness Analysis of Effluent Limitation Guidelines and Standards for the Centralized Waste Treatment Industry

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SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has established effluent limitations guidelines and standards for the centralized waste treatment (CWT) industry. This report explores the cost-effectiveness of the control options EPA considered for the three subcategories of CWT operations. For the final rule, EPA considered two control options for metals, two for oils and one for organics, with four possible combinations of these options.[1] The report measures cost-effectiveness by comparing of compliance costs to the quantity of pollutants removed under each combination of control options. It defines cost of the regulation as the estimated nationally aggregated annualized cost for the industry to comply with the regulation. The report measures the effectiveness of the regulation in terms of reductions in the pounds of pollutants discharged to surface waters, weighted to account for the pollutants' toxicity. While the regulation specifically limits only certain pollutants, others that are not directly regulated are removed as a result of controlling the discharge of the regulated pollutants. The report measures the removal of both regulated and incidentally-removed pollutants.

This analysis measures the quantity of pollutants removed in standardized "pound-equivalents." A pound-equivalent (lb-eq) is a pound of pollutant weighted for its toxicity. Using pound-equivalents reflects the fact that some pollutants are more toxic than others and permits a comparison of removals and, thus, a summary measure of removals. This cost-effectiveness analysis employs the "toxic weighting factor" (TWF) approach for weighting pollutants according to their relative toxicity. EPA has historically used this in developing effluent guidelines. To measure removals, EPA multiplies the total number of pounds per year of each pollutant removed by its corresponding toxic weighting factor (TWF). In its analysis, EPA only includes those toxic pollutants for which it has developed TWFs. This means that the analysis will necessarily understate toxic removals for which EPA has not

[1]Earlier EPA proposals of effluent limitations and standards for CWT facilities reflected consideration of other treatment technology options: one more metals option and one more organics option. EPA eliminated these additional options from further assessments after additional examination.

assigned TWFs. EPA's cost-effectiveness assessment does not analyze removal efficiencies for conventional pollutants, such as oil and grease, biological oxygen demand, and total suspended solids; thus, this report does not address the removal of conventional pollutants.

EPA computes the cost-effectiveness (in dollars per pound-equivalent removed) of a treatment option by summing the costs of complying with the option across all affected dischargers and dividing this cost by the sum of the toxicity-weighted removals for these dischargers. This permits comparison of the cost-effectiveness of the various combinations of options. One way to compare combinations of options is to look at the incremental cost-effectiveness, which measures changes in costs and removals that result from switching from one combination to another.

Cost-effectiveness is a relative measure. Comparisons of cost-effectiveness values are meaningful only when the costs being compared are taken from, or are adjusted to, the same time period. EPA therefore presents the cost-effectiveness in 1981 dollars to facilitate comparisons with the cost-effectiveness of other effluent limitations and guidelines . In addition, EPA estimates the removals using a consistent toxic weighting approach. Generally, lower cost-effectiveness values are preferable to higher values, because they indicate lower average unit costs of removals. However, weighing the factors that the Clean Water Act (CWA) requires EPA to consider in establishing limitations and standards may preclude choosing some regulatory options with low cost-effectiveness values.

Cost-effectiveness values are a useful tool for comparing the relative merits of regulatory options proposed at the same time, for the same group of dischargers in a specific industry. They also provide a limited basis for comparing the efficiency of a regulatory option currently being considered for one industry with the efficiencies of previously promulgated effluent limitations guidelines for other industries. Comparisons across industries may be imperfect, however, because over time, EPA has modified the TWFs used for some pollutants in the development of past effluent guidelines.

Section 2 of this report discusses the methods used for this cost-effectiveness analysis. It details the pollutants included in calculations of pollutant removals, lists the TWFs used to estimate pound-equivalent removals, and describes the subcategory control options that are combined to create the four regulatory options. Section 2 also discusses the differences in how EPA measured removals for direct and indirect dischargers. (Indirect dischargers are facilities whose effluent receives treatment at a publicly owned treatment works [POTW] before it is discharged to surface waters.) In addition, Section 2 describes

how EPA annualized compliance costs, calculated two different cost-effectiveness values, and may compare the merits of each regulatory option. Section 3 presents the findings of this cost-effectiveness analysis and identifies the superior options. Section 4 compares the cost-effectiveness of these options for the CWT industry to the cost-effectiveness of control options that have been proposed for other industries under other promulgated rules.

SECTION 2

BACKGROUND AND METHODOLOGY

As part of the process of developing effluent limitations guidelines and pretreatment standards, EPA uses cost-effectiveness calculations to compare the efficiencies of regulatory options for removing pollutants. The Agency evaluates both overall cost-effectiveness and incremental cost-effectiveness. The overall cost-effectiveness of a control option is the ratio of the annualized cost of that control option to the quantity of pollutants not discharged to surface water because of that option. Incremental cost-effectiveness measures the difference in costs divided by the difference in removals that result from comparing one control option to another control option, or to a benchmark measure. (Cost Option A—Cost Option B)/ (Removals Option A—Removals Option B). Examples of benchmarks include existing treatments and previously promulgated regulations. Although the CWA does not require EPA to base limitations and standards on the most cost-effective treatment options, a cost-effectiveness analysis offers a useful metric for comparing the efficiency of alternative regulatory options in removing toxic pollutants. The analysis compares removals for pollutants directly regulated by the guidelines and standards and incidentally removed along with regulated pollutants. EPA's cost-effectiveness assessment does not analyze removal efficiencies for conventional pollutants, such as oil and grease, biological oxygen demand, and total suspended solids. Thus, this report does not address the removal of conventional pollutants.

EPA's cost-effectiveness analysis includes seven steps:

1. Determine the pollutants considered for regulation–so-called "pollutants of concern."
2. Estimate relative toxic weights for these pollutants.
3. Define pollution control options.
4. Calculate pollutant removals for each control option.
5. Determine the total annualized cost for each control option.

6. Calculate cost-effectiveness values (and adjust to 1981 dollars).

7. Compare cost-effectiveness values.

The following sections discuss these steps as they apply to the CWT industry.

2.1 Pollutants Considered by EPA

In preparing the cost-effectiveness analysis for the CWT industry, EPA considered 146 pollutants. These pollutants include those regulated directly by the guidelines and standards, as well as those pollutants considered for regulation, but not ultimately selected. The analysis includes nonregulated pollutants when they are removed incidentally as a result of a particular treatment technology, even though they are not specifically limited.

The Technical Development Document (TDD) details the pollutants considered for regulation for each subcategory, and the pollutants that were ultimately selected for regulation. Generally, EPA chose not to establish limitations and standards for a particular pollutant for one or more of the following reasons:

- the pollutant was not effectively treated by the option technology (the pollutant level increased across the technology),
- the pollutant was not detected at treatable levels in the influent streams at the facilities forming the basis for the options limitations and standards,
- the pollutant is pervasive in the environment as a mineral and is relatively nontoxic (for example, calcium),
- the pollutant is often used as a treatment chemical, and
- the pollutant's TWF is zero.

Table 2-1 lists the pollutants that are considered in the cost-effectiveness analysis and presents their TWFs and POTW removal efficiencies.[1] The table lists all nonconventional pollutants (out of the 146 pollutants of concern) for the sake of completeness, even if their TWF is zero.

[1]See the Technical Development document for a description of POTW removal efficiencies.

Table 2-1. Pollutants of Concern for CWT Industry and Toxic Weighting Factors

Pollutant Name	Toxic Weighting Factor	POTW Removal Percentage
Metals		
Aluminum	0.06440	91.36
Antimony	0.00500	66.78
Arsenic	3.50000	65.77
Barium	0.00200	55.15
Beryllium	5.29903	61.23
Boron	0.18000	23.66
Cadmium	2.60000	90.05
Calcium	0.00003	8.54
Chloride	0.00002	24.67
Chromium	0.07600	80.33
Cobalt	0.11000	10.19
Copper	0.63000	84.20
Fluoride	0.03500	53.72
Germanium	18.66667	50.00
Iodine	0.00000	39.25
Iridium	0.00000	74.00
Iron	0.00560	81.99
Lead	2.20000	77.45
Lithium	0.01200	26.00
Magnesium	0.00000	14.14
Manganese	0.07000	35.51
Mercury	120.00000	90.16
Molybdenum	0.20000	18.93
Nickel	0.11000	51.44
Phosphorus	0.00000	69.42
Potassium	0.00105	39.51
Selenium	1.10000	34.33
Silicon	0.00000	27.29
Silver	16.00000	88.28
Sodium	0.00001	2.69
Strontium	0.00001	14.83
Sulfur	0.00001	14.33
Tin	0.30000	42.63
Titanium	0.02930	91.82
Vanadium	0.62000	8.28
Yttrium	*	21.04
Zinc	0.04700	79.14
Zirconium	0.54000	54.97

(continued)

Table 2-1. Pollutants of Concern for CWT Industry and Toxic Weighting Factors (continued)

Pollutant Name	Toxic Weighting Factor	POTW Removal Percentage
Organics		
1-methylfluorene	0.049000	84.55
1-methylphenanthrene	0.100000	84.55
1,1-dichloroethene	0.180000	70.00
1,1,1-trichloroehtane	0.004300	90.45
1,1,1,2-tetrachloroethane	0.024000	54.89
1,1,2-trichloroethane	0.014000	55.98
1,2-dibromoethane	44.000000	17.00
1,2-dichloroethane	0.006200	89.03
1,2,3-trichloropropane	0.001960	5.00
1,2,4-trichlorobenzene	0.082000	91.52
1,4-dichlorobenzene	0.077000	52.35
1,4-dioxane	0.000228	45.80
2-butanone	0.000025	96.60
2-methylnaphthalene	0.080000	28.00
2-phenylnaphthalene	0.150000	84.55
2-Propanone	0.000005	83.75
2,3-benzofluorene	0.160000	84.55
2,3-dichloroaniline	0.007800	41.00
2,3,4,6-tetrachlorophenol	0.052000	33.00
2,4-dimethylphenol	0.005300	51.22
2,4,5-trichlorophenol	0.026000	28.00
3,6-dimethylphenanthrene	0.270000	84.55
4-chloro-3-methylphenol	0.004300	63.00
4-methyl-2-pentanone	0.000120	87.87
acenapthene	0.029000	98.29
acetophenone	0.000240	95.34
alpha-terpinol	0.001100	94.40
aniline	1.405895	93.41
anthracene	2.500000	95.56
benzene	0.018000	94.76
benzoic Acid	0.000330	80.50
benzo(a)anthracene	180.000000	97.50
benzyl alcohol	0.005600	78.00
biphenyl	0.029000	96.28
bis(2-ethylhexyl) phthalate	0.095000	59.78
Butanone	0.000025	96.60
butyl benzyl phthalate	0.023000	94.33
carbazole	0.270000	62.00
carbon disulfide	2.800000	84.00

(continued)

Table 2-1. Pollutants of Concern for CWT Industry and Toxic Weighting Factors (continued)

Pollutant Name	Toxic Weighting Factor	POTW Removal Percentage
Organics (continued)		
chlorobenzene	0.002900	96.37
chloroform	0.002100	73.44
chrysene	2.100000	96.90
di-n-butyl phthalate	0.012000	79.31
dibenzofuran	0.200000	97.80
dibenzothiopene	0.046000	84.68
dibromochloromethane	0.130000	81.60
diethyl ether	0.000077	7.00
diethyl phthalate	0.000610	59.73
diphenyl ether	0.026000	97.80
ehtylbenzene	0.001400	93.79
fluoranthene	0.800000	42.46
fluorene	0.700000	69.85
hexanoic acid	0.000370	84.00
m-xylene	0.001500	95.07
methylene chloride	0.000420	54.28
n-decane	0.004300	9.00
n-docosane	0.000082	88.00
n-dodecane	0.004300	95.05
n-eicosane	0.004300	92.40
n-hexacosane	0.004300	71.11
n-hexadecane	0.004300	71.11
n-nitrosomorpholine	0.000002	81.60
n-octadecane	0.004300	71.11
n-tetracosane	0.004300	71.11
n-tetradecane	0.004300	71.11
naphthalene	0.015000	94.69
n,n-dimethylformamide	0.000008	87.00
o-cresol	0.002700	52.50
o+p xylene	0.004700	65.40
p-cresol	0.004000	71.67
p-cymene	0.024000	99.79
pentachlorophenol	0.440000	13.88
pentamethylbenzene	0.055000	91.23
phenanthrene	0.290000	94.89
phenol	0.028000	95.25
pyrene	0.110000	83.90
pyridine	0.001300	95.40
styrene	0.014000	93.65

(continued)

Table 2-1. Pollutants of Concern for CWT Industry and Toxic Weighting Factors (continued)

Pollutant Name	Toxic Weighting Factor	POTW Removal Percentage
Organics (continued)		
tetrachloroethylene	0.013000	84.61
tetrachloromethane	0.130000	87.94
toluene	0.005600	96.18
trans-1,2-dichloroethene	0.000930	70.88
trichloroethylene	0.006400	86.85
tripropyleneglycol Methyl Ether	0.000008	52.40
vinyl chloride	0.120000	93.39

2.2 Relative Toxic Weights of Pollutants

EPA's cost-effectiveness analysis accounts for differences in toxicity among pollutants of concern through the use of TWFs as explained in Section 1. These weighting factors offer a way to compare, on a common basis, quantities of different pollutants, each with different potential effects on human and aquatic life.

The TWFs that EPA has traditionally used to develop effluent guidelines and standards are based on two values: the chronic aquatic life value and the human health value. The chronic aquatic life value indicates the concentration in water at which a pollutant has a toxic effect on aquatic life. It is measured in µg/L. The human health value, also measured in µg/L, indicates the concentration in water that would cause harm to humans eating at least 6.5 grams of fish per day from that water. (For carcinogenic substances, a harmful level is considered to be a concentration that would lead to more than 1 in 100,000 additional cancer cases over background.) This analysis standardizes these values by relating them to copper, a toxic metal pollutant that is commonly detected and removed from industrial effluent. EPA uses the value of 5.6 µg/L as the benchmark figure because, at this concentration, copper becomes toxic. (This is the former water quality value for copper, which has been revised to 12 µg/L. The Agency still uses the former value, however, to allow comparisons with cost-effectiveness values for previously promulgated guidelines and limitations.) TWFs are calculated as follows:

$$TWF = 5.6/AQ + 5.6/HH$$

where

TWF = toxic weighting factor,

AQ = chronic aquatic life value (μg/L), and

HH = human health value (μg/L).

First, EPA estimated the ratio of the baseline value (5.6 μg/L) to the human health value for that pollutant. Then, EPA estimated the ratio of the baseline value (5.6 μg/L) to the aquatic life value for that pollutant. Finally, the analysis summed these two values.

Table 2-2 further illustrates the process for calculating each TWF. This table shows that because the water quality criterion for copper has been revised to 12.0 μg/L, the TWF for copper is 0.467 rather than 1, the weighting factor that one would normally expect for a benchmark pollutant. It also shows how high human health and aquatic figures lead to low TWFs. In other words, if a pollutant causes adverse effects only at high concentrations, then it will have a low TWF.

Table 2-2. TWFs Based on Copper Criteria

Pollutant	Human Health Value (μg/L)	Chronic Aquatic Life Value (μg/L)	Calculation	Toxic Weighting Factor
Copper	–	12.0	5.6/12.0	0.467
Lead	–	3.2	5.6/3.2	1.750
Nickel	4,600	160.0	5.6/4,600 + 5.6/160	0.036
Cadmium	84	1.1	5.6/84 + 5.6/1.1	5.158
Benzene	710	530.0	5.6/710 + 5.6/530	0.018

Table 2-2 shows how 11.04 pounds of copper pose the same relative hazard in surface waters as 1 pound of cadmium, because cadmium has a TWF that is 11.04 times as large as the TWF for copper (5.158/0.467 = 11.04). Similarly, by the TWF method, 97.22 pounds of benzene present the same net risk as a single pound of lead, because the TWF for lead is 97.22 as large (1.75/0.018 = 97.22) as the TWF for benzene. By multiplying the reduction in

industry loadings (lbs/yr) of each pollutant by each pollutant's corresponding copper-based TWF and summing this product across all pollutants of concern, the Agency can derive the total TWF-weighted pollutant removals (lbs-equivalent/yr) attributable to each proposed regulatory option.

2.3 Pollution Control Options

The final effluent limitations guidelines and standards for the CWT industry apply to wastewater discharges generated during the treatment or recovery of hazardous and nonhazardous industrial waste received from off-site. The proposed effluent guidelines and standards were developed for three subcategories:

- metal-bearing waste treatment and recovery,
- oily waste treatment and recovery, and
- organic waste treatment and recovery.

EPA considered a total of five control options for the CWT industry, each applicable to one of the three subcategories to be regulated. Table 2-3 offers a brief description of each control option and identifies the subcategory to which it applies. Additional information on the control options can be found in the Agency's TDD.

Table 2-3. Descriptions of the Individual CWT Control Options

Treatment Subcategory	Control Option Number	Control Option Name	Control Option Description
Metals	2	MET3	Selective metals precipitation, liquid-solid separation, secondary precipitation, liquid-solid separation, tertiary separation, and clarification.
	3	MET4	Batch precipitation, liquid-solid separation, secondary precipitation, and sand filtration.
Oils	1	OIL8	Emulsion breaking/gravity separation and dissolved air flotation.
	2	OIL9	Emulsion breaking/gravity separation, secondary gravity separation, and dissolved air flotation.
Organics	2	ORG4	Equalization and biological treatment.

2.4 Calculation of Pollutant Removals

EPA's analysis calculated the reduction in pollutant loadings released by each CWT facility to receiving waters for each control option. Appendix A shows these reductions in detail. These *at-stream* pollutant removals are equal to *end-of-pipe* (i.e., at the edge of the facility) pollutant removals for direct dischargers. For indirect dischargers, however, at-stream and end-of-pipe removals may differ because a portion of the end-of-pipe pollutant loadings for indirect dischargers may be removed by the POTW where the CWT facility's sewage receives some wastewater treatment before it is ultimately discharged to surface waters. Therefore, pollutant loadings discharged to surface water from an indirect discharging facility may be less than pollutant loadings leaving the facility. This analysis bases the comparison of removals across control options at the point of discharge into surface water. Thus, the analysis adjusts removals at indirect discharging facilities to account for pollutants removed by the POTW.

For example, if a facility is discharging 100 pounds of cadmium in its effluent stream to a POTW, and the POTW has a removal efficiency for cadmium of 90.05 percent, then 90.05 pounds of the cadmium discharged by the facility would be removed from the facility's effluent when the wastewater is initially treated at the POTW. The amount of cadmium that is ultimately discharged to surface waters would only amount to 9.05 pounds. If the indirect discharging facility then changes its waste treatment operations to comply with the regulation and thereby dramatically reduces the amount of cadmium in its end-of-pipe discharges to the sewer system, only a portion of these end-of-pipe pollutant discharge reductions qualify as at-stream pollutant removals. Thus, if an indirect discharger cut its baseline indirect discharges of cadmium from 100 pounds to 60 pounds, the net reduction in cadmium discharged to surface waters attributable to the regulation is not 40 percent of its baseline discharges to the sewer system (40 pounds), but rather 40 percent of the 9.95 pounds of the CWT facility's cadmium that are ultimately discharged to surface waters at baseline (3.98 pounds).

Table 2-4 presents two different estimates of the annual mass loading of at-stream pollutant removals anticipated from direct and indirect dischargers for each control option. The top section of the table shows estimated total pollutant removals (lbs/yr) for each control option for all nonconventional and priority pollutants considered, without weighting the individual pollutants removed according to their toxicity. This part of the table shows mass loading reductions that include expected removals of the CWT pollutants excluded from the

Table 2-4. Summary of Weighted and Unweighted Pollutant Removals for Direct and Indirect Dischargers

Weighting Method	Control Option Name	Total Removals by Direct Dischargers (lbs/yr)	Total Removals by Indirect Dischargers (lbs/yr)	Total Removals by All Dischargers (lbs/yr)
Unweighted				
	MET3	165,259,000	155,856,000	321,116,000
	MET4	86,649,000	76,539,000	163,188,000
	OIL8	5,699,000	106,766,000	112,465,000
	OIL9	4,982,000	99,116,000	104,098,000
	ORG4	0	2,002,100	2,002,100
TWF				
	MET3	395,034	47,482	442,516
	MET4	378,055	38,906	416,961
	OIL8	1,721	48,039	49,760
	OIL9	1,764	50,684	52,448
	ORG4	0	19,814	19,814

cost-effectiveness analysis because information about their relative toxicity is lacking or their TWF is zero. The lower section of the table presents the weighted mass loading reductions attributable to each control option. These values are based only on weighted removals of the pollutants for which TWFs have been estimated.

2.5 Annualized Cost for Each Control Option

EPA's Technical Development Document describes the methods used to estimate the costs of complying with the regulatory options. This section provides a brief summary of the compliance costs.

EPA evaluated four categories of compliance costs: capital costs, land costs, operating and maintenance costs (including sludge disposal), and monitoring costs. While the operating and maintenance and monitoring costs are annual costs, the capital and land are one-time "lump-sum" costs. Because these lump-sum expenditures are too large for most CWT facilities to finance out of current revenues; they will probably be paid for by equity or debt financing. Therefore, EPA annualized these costs over the expected life of the capital equipment to better represent the annual cost of financing the lump-sum cost. EPA assumed the capital and land to have a productive life of 20 years. Therefore, the Agency annualized these lump-sum costs over a period of 20 years using company-specific interest rates (real weighted average cost of capital or RWACC). For facilities responding to the Agency's 1991 Waste Treatment Industry Questionnaire, the estimated RWACC reflects company-specific information provided. For facilities that did not provide this information, the Agency assumes an RWACC of 7 percent. It is important to note that the Agency gives indirect discharging facilities an extra 2 years to comply with the regulation, effectively lowering the costs of compliance for these facilities. The report presents cost-effectiveness values using pre-tax costs. For more detail on the cost annualization, see Section 4 of the EA.

2.6 Calculation of Cost-Effectiveness Values

Typically, the cost-effectiveness value for a particular control option is the ratio of incremental annual cost of that option to the incremental pound-equivalents removed by that option. The incremental effectiveness can be viewed both in comparison to the baseline scenario and to another regulatory option. The analysis reports cost-effectiveness values in units of dollars per pound-equivalent of pollutant removed. For the purpose of comparing cost-effectiveness values of options under review to those of other promulgated rules, EPA adjusted compliance costs used in the cost-effectiveness analysis to 1981 dollars using *Engineering News Record's* Construction Cost Index (CCI). This adjustment factor is calculated as follows:

$$\text{Adjustment factor} = CCI_{1981}/CCI_{\text{Current Year}} =$$

The equation used to calculate incremental cost-effectiveness is

$$CE_k = (TAC_k - TAC_{k-1})/(Pe_k - PE_{k-1})$$

where

CE_k = incremental cost-effectiveness of Option k,

TAC_k = total annualized cost of compliance under Option k, and

PE_k = pound-equivalents removed by Option k.

The numerator of the equation, TAC_k minus TAC_{k-1}, is simply the incremental annualized treatment cost in going from Option k-1 to Option k. The denominator is similarly the incremental removals achieved in going from Option k-1 to Option k. Thus, the incremental cost-effectiveness of Option k represents the unit cost of additional pound-equivalent removals (beyond what is achievable by Option k-1), assuming that the removals achievable by Option k-1 can be removed for the average unit cost of Option k-1. In other words, incremental cost-effectiveness values show how much more it would cost per incremental pound-equivalent of pollutant removed to raise the effluent guideline from one level of stringency to the next higher level of stringency.

The method of comparing average cost-effectiveness values of options to current treatment uses the same formula and sets the benchmark costs (TAC_{k-1}) equal to zero. For the total cost-effectiveness method, the benchmark pollutant removals (PE_{k-1}) are set equal to zero.

2.7 Comparisons of Cost-Effectiveness Values

Two types of comparisons are typically presented using cost-effectiveness values. In addition to being presented in tabular form, the data are plotted with compliance costs on the y axis, and pollutant removals on the x axis to visually identify the efficient regulatory options. Alternatively, cost-effectiveness values are compared to other cost-effectiveness values that have been previously estimated for promulgated effluent limitations guidelines for other industries. The comparison of CWT cost-effectiveness with that of other effluent limitations guidelines is presented in Section 4.

SECTION 3

COST-EFFECTIVENESS RESULTS

EPA prepared the cost-effectiveness analyses on the five individual control options described in Table 2-3 and on the combined regulatory option. In each case, EPA analyzed the cost-effectiveness of the regulatory options separately for direct and indirect dischargers.

This section first presents the total costs, total removals, cost-effectiveness, and incremental cost-effectiveness values for each separate regulatory option, for each subcategory. Then it presents this information for the combined regulatory options and further examines the most efficient options.

3.1 Cost-Effectiveness of Individual Control Options

Tables 3-1 and 3-2 present the total cost, total removals, cost-effectiveness, and incremental cost-effectiveness values associated with each individual control option for direct and indirect dischargers, respectively. Options are ordered, withing each subcategory (metals, oils, or organics), by pounds-equivalent removed. The tables present costs in $1997 (to facilitate comparison with other documents, particularly the EA) and in $1981 (to maintain comparability with previously promulgated effluent guidelines).

Calculating incremental cost-effectiveness values involves sorting the regulatory options in order of increasing removals. EPA calculates incremental cost-effectiveness values by dividing the change in total annualized cost of compliance by the change in removals, as described in Section 2.6. Regulatory options that are cost-effective (superior) have the same removals at lower cost than other options or have higher removals at the same or lower cost than other options.

Table 3-1 shows that for direct dischargers Metals 4 has lower cost than Metals 3. For oils, both options have the same cost, but Oils 9 has slightly higher removals than Oils 8. There are no TWF-weighted removals for Organics 4 for direct dischargers. Table 3-2 shows that for indirect dischargers, Metals 4 also has the lower cost. Oils 9 provides higher removals than Oils 8, but at higher cost. Organics 4 is the most cost-effective of all of the individual control options.

Table 3-1. Cost-Effectiveness Comparison of Individual Control Options for Direct Discharging CWT Factilities

Control Option Name	Costs ($1997)	Costs ($1981)	Removals (lbs-eq)	Cost-Effectiveness ($1981/lb-eq)	Incremental Cost-Effectiveness ($1981)
Individual Costs and Removals					
Metals 4	$3,544,898	$2,151,291	378,055	$6	—
Metals 3	$14,832,434	$9,001,355	395,034	$23	$403
Oils 8	$542,354	$329,138	1,721	$191	—
Oils 9	$542,354	$329,138	1,764	$187	—
Organics 4	$221,942	$134,690	—	—	—

Table 3-2. Cost-Effectiveness Comparison of Individual Control Options for Indirect Discharging CWT Facilities

Control Option Name	Costs ($1997)	Costs ($1981)	Removals (lbs-eq)	Cost- Effectiveness ($1981/lb-eq)	Incremental Cost-Effectiveness ($1981)
Individual Costs and Removals					
Metals 4	$11,449,581	$6,948,403	38,906	$179	$179
Metals 3	$44,350,240	$26,914,817	47,482	$567	$2,328
Oils 8	$14,797,636	$8,980,237	48,039	$187	$187
Oils 9	$21,085,721	$12,796,285	50,684	$252	$1,443
Organics 4	$4,592,799	$2,787,230	19,814	$141	$141

3.2 Cost-Efectiveness of Combined Regulatory Option

Cost-effectiveness values for individual control options alone do not provide enough information to guide the Agency in selecting an optimal regulatory option, because each proposed control option only applies to one of the three subsets of wastes treated in CWT operations covered by these guidelines. Three individual control options (one addressing each subcategory of waste managed in affected CWT operations) must be combined to create each regulatory option capable of meeting the Agency's regulatory responsibilities. Table 3-3 shows the combined cost-effectiveness results for the combined option for direct and indirect dischargers.

Table 3-3. Cost-Effectiveness of Combined Regulatory Options for Discharging CWTs by Discharge Status

Discharge Status	Regulatory Option	Total Costs ($1981)	Total TWF Removals (lb eq.)	Cost-Effectiveness ($/lb eq.)
Direct	**Met 4 Oil 9 Org 4**	$2,615,119	379,819	$7
Indirect	**Met 4 Oil 8 Org 4**	$18,715,871	106,759	$175

SECTION 4

COMPARISON OF THE COST-EFFECTIVENESS OF SELECTED CWT REGULATORY OPTIONS WITH THE COST-EFFECTIVENESS OF PREVIOUSLY APPROVED EFFLUENT GUIDELINES AND STANDARDS

Table 4-1 compares the estimated cost-effectiveness of the final effluent limitations for direct discharging CWT facilities to the cost-effectiveness of best achievable technology (BAT) regulations that have been approved for direct dischargers in other industries. Table 4-2 provides a similar comparision for indirect dischargers. This type of comparison is only possible using the cost-effectiveness values that are derived with pound-equivalent removals estimated using the TWF weighting approach. All costs are in 1981 dollars.

Table 4-1. Industry Comparison of BAT Cost-Effectiveness for Direct Dischargers

Industry	Currently Discharged (10^3 lb. eq.)[a]	Remaining at Selected Option(s) (10^3 lb. eq.)[a]	Cost-Effectiveness of Selected Option(s) ($1981/lb. eq.)
Aluminum Forming	1,340	90	121
Battery Manufacturing	4,126	5	2
Canmaking	12	0.2	10
Centralized Waste Treatment			7
Coal Mining	BAT=BPT	BAT=BPT	BAT=BPT
Coil Coating	2,289	9	49
Copper Forming	70	8	27
Electronics I	9	3	404
Electronics II	NA	NA	NA
Foundries	2,308	39	84
Industrial Waste Combustor[b]			
A			66
B			65
Inorganic Chemicals I	32,503	1,290	<1
Inorganic Chemicals II	605	27	6
Iron and Steel	40,746	1,040	2
Landfills[b]			13,346
Leather Tanning	259	112	BAT=BPT
Metal Finishing	3,305	3,268	12
Metal Products and Machinery[b]	140	70	50
Nonferrous Metals Forming	34	2	69
Nonferrous Metals Manufacturing I	6,653	313	4
Nonferrous Metals Manufacturing II	1,004	12	6
Offshore Oil and Gas[c]	3,809	2,328	33
Coastal—Produced Water/TWC	951	239	35
Drilling Waste	BAT=current practice	BAT=current practice	BAT=current practice
Organic Chemicals	54,225	9,735	5
Pesticides	2,461	371	15
Pharmaceuticals[b]			
A/C	897	47	47
B/D	90	0.5	96
Plastics Molding and Forming	44	41	BAT=BPT
Porcelain Enameling	1,086	63	6
Petroleum Refining	BAT=BPT	BAT=BPT	BAT=BPT
Pulp and Paper	61,713	2,628	39
Textile Mills	BAT=BPT	BAT=BPT	BAT=BPT
TEC: TR/CHEM&PETR	BAT=BPT	BAT=BPT	BAT=BPT
TT & RT/CHEM&PETR	1	ND	323

[a] TWFs for some priority pollutants have changed across these rules; this table reflects the cost-effectiveness at the time of regulation.

[b] Proposed.

[c] Produced water only, for produced sand and drilling fluids and drill cuttings, BAT=NSPS.

Table 4-2. Industry Comparison of PSES Cost-Effectiveness for Indirect Dischargers

Industry	Pollutants Currently Discharged (10^3 lb. eq.)[a]	Pollutants Remaining at Selected Option (10^3 lb. eq.)[a]	Cost-Effectiveness of Selected Option(s) ($1981/lb. eq.)
Aluminum Forming	1,602	18	155
Battery Manufacturing	1,152	5	15
Canmaking	252	5.0	38
Centralized Waste Treatment			175
Coal Mining	NA	NA	NA
Coil Coating	2,503	10	10
Copper Forming	34	4	10
Electronics I	75	35	14
Electronics II	260	24	14
Foundries	2,136	18	116
Industrial Waste Combustor[b]			
A			85
B			88
Inorganic Chemicals I	3,971	3,004	9
Inorganic Chemicals II	4,760	6	<1
Iron and Steel	5,599	1,404	6
Leather Tanning	16,830	1,899	111
Metal Finishing	11,680	755	10
Metal Products and Machinery[b]	1,115	234	127
Nonferrous Metals Forming	189	5	90
Nonferrous Metals Manufacturing I	3,187	19	15
Nonferrous Metals Manufacturing II	38	0	12
Organic Chemicals	5,210	72	34
Pesticide Manufacturing	257	19	18
Pesticide Formulating	7,746	112	<3
Pharmaceuticals[b]	340	63	1
Plastics Molding and Forming	NA	NA	NA
Porcelain Enameling	1,565	96	14
Pulp and Paper[b]	9,539	103	65
Transportation Equipment Cleaning	38	19	380

[a] TWFs for some priority pollutants have changed across these rules; this table reflects the cost effectiveness at the time of regulation.

[b] Proposed.

APPENDIX A

Detailed Pollutant Loadings and Removals Data

The following tables give detailed information concerning loadings and removals of pollutants. Tables A-1 through A-4 provide a summary of the pollutant loadings and removals for the CWT metals, oils, organics, and the entire industry, respectively. Table A-5 provides the pound-equivalent removals for the considered options.

TABLE A-1. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT METALS SUBCATEGORY[a]

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Wastewater Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Conventionals								
Biochemical Oxygen Demand 5-Day (BOD_5)	5,237,757	607,741	622,073	60,587	4,615,684	547,154	0	0
Oil and Grease (measured as HEM)	203,157	34,919	97,156	15,729	106,001	19,190	0	0
Total Suspended Solids (TSS)	4,113,843	214,393	68,993	7,088	4,044,849	207,305	0	0
Priority Organics								
1,1,1-Trichloroethane	354	44	21	2	333	42	0	1
1,1-Dichloroethene	439	174	16	5	423	169	76	30
Methylene Chloride	461	261	30	13	432	248	0	0
Toluene	1,137	55	353	15	784	41	4	0
Trichloroethylene	508	56	508	56	0	0	0	0
Total Priority Organics	**2,899**	**590**	**928**	**90**	**1,971**	**500**	**82**	**31**
Non-conventional Organics								
2-Propanone	8,945	354	8,945	354	0	0	0	0
Benzoic Acid	11,172	1,053	5,610	451	5,562	602	2	0
Butanone	900	8	900	8	0	0	0	0
Carbon Disulfide	106	7	106	7	0	0	0	0
Dibromochloromethane	319	70	193	38	126	32	16	4
n,n-Dimethylformamide	210	6	113	6	97	1	0	0
n-Nitrosomorpholine	47	2	44	2	4	0	0	0
Pyridine	74	1	74	1	0	0	0	0
Tripropyleneglycol Methyl Ether	765	93	765	93	0	0	0	0
Total Non-conventional organics	**22,538**	**1,593**	**16,749**	**959**	**5,789**	**634**	**18**	**4**

(continued)

TABLE A-1. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT METALS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Wastewater Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Priority Metals								
Antimony	21,921	4,848	608	228	21,313	4,620	102	22
Arsenic	2,422	270	509	197	1,913	72	6,697	254
Cadmium	27,060	459	233	23	26,827	436	69,751	1,133
Chromium	143,277	4,968	5,751	1,286	137,527	3,682	10,452	280
Copper	197,102	1,547	2,385	438	194,717	1,109	122,672	699
Lead	17,586	1,539	712	155	16,874	1,385	37,123	3,047
Mercury	78	7	2	0	76	7	9,148	825
Nickel	92,838	33,806	4,341	2,194	88,497	31,612	9,735	3,477
Selenium	1,473	840	1,433	826	39	14	43	16
Silver	773	94	95	12	678	82	10,844	1,307
Zinc	148,751	2,460	1,481	325	147,270	2,135	6,922	100
Total PriorityMetals	**653,281**	**50,839**	**17,550**	**5,684**	**635,731**	**45,155**	**283,488**	**11,159**
Non-conventional Metals								
Aluminum	130,801	9,511	3,042	299	127,759	9,212	8,228	593
Beryllium	21	6	21	6	0	0	0	0
Boron	136,007	100,815	34,055	25,900	101,952	74,915	18,351	13,485
Calcium	10,871,659	13,016,704	82,743	73,852	10,788,916	12,942,852	302	362
Chloride	122,565,384	106,473,294	63,611,507	54,729,374	58,953,877	51,743,920	1,433	1,257
Cobalt	18,608	1,050	437	415	18,171	635	1,999	70
Fluoride	388,986	103,234	194,444	97,928	194,542	5,306	6,809	186
Iridium	26,650	6,562	2,069	525	24,581	6,037	0	0
Iron	131,733	11,275	24,045	4,947	107,688	6,328	603	35
Lithium	99,930	90,686	7,971	5,756	91,959	84,930	1,104	1,019

(continued)

TABLE A-1. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT METALS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Wastewater Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Metals (continued)								
Magnesium	40,103	20,183	40,103	20,183	0	0	0	0
Manganese	15,721	3,945	176	127	15,545	3,818	1,088	267
Molybdenum	24,338	17,538	6,465	5,717	17,873	11,821	3,575	2,364
Phosphorus	1,157,223	214,847	86,933	30,559	1,070,290	184,288	0	0
Potassium	6,830,501	5,095,607	1,468,873	1,001,254	5,361,628	4,094,353	5,644	4,310
Silicon	38,785	12,249	5,288	4,247	33,497	8,002	0	0
Sodium	57,998,864	62,663,606	53,149,361	57,507,406	4,849,502	5,156,200	27	28
Strontium	16,057	16,776	414	344	15,643	16,432	0	0
Sulfur	9,037,707	6,334,649	5,022,530	4,199,022	4,015,178	2,135,627	22	12
Tin	131,627	6,061	329	206	131,297	5,855	39,389	1,757
Titanium	74,127	152	196	19	73,931	134	2,166	4
Vanadium	4,451	250	49	44	4,402	206	2,729	128
Yttrium	134	97	21	16	113	81	0	0
Zirconium	6,750	3,214	5,300	2,339	1,450	875	783	472
Total Non-conventional Metals	**209,746,164**	**194,202,309**	**123,746,371**	**117,710,483**	**85,999,792**	**76,491,826**	**94,251**	**26,350**
Classical Parameters								
Ammonia as N	995,930	753,634	59,080	38,532	936,850	715,102	1,686	1,287
Chemical Oxygen Demand (COD)	35,205,287	8,289,423	4,791,127	1,006,656	30,414,161	7,282,767	0	0
Cyanide, Total	2,478	12,261	1,314	8,012	1,164	4,259	6,577	1,872
Hexavalent Chromium	340,656	18,648	2,917	2,841	337,739	15,807	172,247	8,062
Total Dissolved Solids (TDS)	187,507,090	190,216,364	158,743,640	158,081,113	28,763,450	32,135,251	0	0
Total Organic Carbon (TOC)	9,814,737	3,694,951	866,786	283,579	8,947,950	3,411,371	0	0

[a]All loadings and reductions take into account the removals by POTWs for indirect discharges.
HEM - Hexane extractable material

TABLE A-2. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT OILS SUBCATEGORY[a]

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Conventionals								
Biochemical Oxygen Demand 5-Day (BOD_5)	1,502,944	7,359,481	1,170,476	4,291,879	332,468	3,067,603	0	0
Oil and Grease (measured as HEM)	206,540	5,563,908	5,574	31,431	200,965	5,532,477	0	0
Total Suspended Solids (TSS)	428,553	2,278,482	96,593	409,624	331,960	1,868,858	0	0
Priority Organics								
1,1,1-Trichloroethane	1	303	1	61	0	242	0	1
1,1-Dichloroethene	0	128	0	112	0	16	0	3
1,2,4-Trichlorobenzene	7	428	7	73	0	355	0	29
1,2-Dichloroethane	0	39	0	39	0	0	0	0
1,4-Dichlorobenzene	7	950	7	319	0	631	0	49
2,4-Dimethylphenol	9	764	9	764	0	0	0	0
Acenapthene	2	37	2	11	0	26	0	1
Anthracene	4	124	4	28	0	96	0	239
Benzene	12	427	12	155	0	272	0	5
Benzo(a)anthracene	3	31	3	11	0	20	0	3,610
Bis(2-ethylhexyl) Phthalate	33	31,740	12	211	21	31,529	2	2,995
Butylbenzyl Phthalate	54	774	11	26	43	748	1	17
Chlorobenzene	0	8	0	6	0	1	0	0
Chloroform	0	197	0	168	0	28	0	0
Chrysene	5	53	5	12	0	41	0	85
Diethylphthalate	5	1,192	5	618	0	575	0	0
Di-n-butyl phthalate	4	140	4	76	0	64	0	1

(continued)

TABLE A-2. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT OILS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Priority Organics (continued)								
Ethylbenzene	9	520	9	132	0	388	0	1
Fluoranthene	2	2,175	2	81	0	2,094	0	1,676
Fluorene	4	775	4	241	0	534	0	374
Naphthalene	69	1,363	49	110	20	1,254	0	19
Phenanthrene	21	523	16	35	5	488	1	142
Phenol	376	2,735	376	2,735	0	0	0	0
Pyrene	34	1,172	11	78	23	1,094	3	120
Tetrachloroethylene	40	1,297	40	546	0	751	0	10
Toluene	44	1,477	44	572	0	905	0	5
Trichloroethene	0	175	0	149	0	26	0	0
Total Priority Organics	**746**	**49,544**	**635**	**7,367**	**112**	**42,177**	**7**	**9,380**
Non-conventional Organics								
1,4-Dioxane	1	296	1	296	0	0	0	0
1-Methylfluorene	5	212	5	42	0	169	0	8
1-Methylphenanthrene	12	389	11	69	2	319	0	32
2,3-Benzofluorene	7	403	7	69	0	334	0	53
2-Methylnaphthalene	46	11,066	32	960	14	10,106	1	808
2-Phenylnaphthalene	3	317	3	19	0	298	0	45
2-Propanone	191	41,336	191	41,336	0	0	0	0
3,6-Dimethylphenanthrene	7	401	7	66	0	335	0	90
4-Chloro-3-methylphenol	28	7,994	28	1,673	0	6,321	0	27
4-Methyl-2-pentanone	15	1,369	15	1,369	0	0	0	0

(continued)

TABLE A-2. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT OILS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Organics (continued)								
Alpha-terpinol	7	134	7	109	0	24	0	0
Aniline	2	50	2	50	0	0	0	0
Benzoic Acid	358	13,146	358	13,146	0	0	0	0
Benzyl Alcohol	31	998	16	141	15	857	0	5
Biphenyl	26	172	26	40	1	132	0	4
Carbazole	3	414	3	270	0	144	0	39
Carbon Disulfide	5	170	5	36	0	134	0	375
Dibenzofuran	2	44	2	13	0	30	0	6
Dibenzothiopene	6	241	6	72	0	169	0	8
Diphenyl Ether	36	106	36	84	0	22	0	1
Hexanoic Acid	1,239	26,761	1,239	8,876	0	17,885	0	7
m-Xylene	10	563	10	190	0	373	0	1
n,n-Dimethylformamide	2	117	2	117	0	0	0	0
n-Decane	45	99,584	45	1,790	0	97,794	0	421
n-Docosane	108	1,970	4	21	104	1,949	0	0
n-Dodecane	251	5,810	46	97	205	5,713	1	25
n-Eicosane	37	3,531	10	33	26	3,498	0	15
n-Hexacosane	10	900	10	900	0	0	0	0
n-Hexadecane	1,926	116,424	502	6,136	1,424	110,288	6	474
n-Octadecane	155	33,724	40	488	115	33,235	0	143
n-Tetracosane	12	1,209	12	1,209	0	0	0	0
n-Tetradecane	1,139	123,867	650	7,951	489	115,916	2	498
o+p-Xylene	11	2,834	11	1,540	0	1,294	0	6

(continued)

TABLE A-2. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT OILS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Organics (continued)								
o-Cresol	30	2,594	30	2,594	0	0	0	0
p-Cresol	23	1,225	23	1,198	0	28	0	0
p-Cymene	20	8	11	1	9	7	0	0
Pentamethylbenzene	7	290	7	35	0	255	0	14
Pyridine	1	36	1	36	0	0	0	0
Styrene	4	61	4	26	0	36	0	0
Tripropyleneglycol Methyl Ether	111	36,723	93	1,887	18	34,836	0	0
Total Non-conventional Organics	**5,930**	**537,487**	**3,508**	**94,986**	**2,422**	**442,501**	**12**	**3,106**
Priority Metals								
Antimony	38	407	19	233	19	174	0	1
Arsenic	12	845	12	588	0	256	0	897
Cadmium	4	35	1	6	3	29	7	76
Chromium	32	800	32	221	0	579	0	44
Copper	123	3,236	22	149	101	3,087	64	1,945
Lead	143	2,987	19	185	124	2,801	273	6,163
Mercury	3	7	1	2	2	5	274	610
Nickel	175	18,427	175	3,794	0	14,633	0	1,610
Selenium	3	161	3	157	0	4	0	4
Silver	1	100	1	100	0	0	0	0
Zinc	2,131	20,387	399	3,421	1,732	16,966	81	797
Total Priority Metals	**2,665**	**47,391**	**685**	**8,857**	**1,980**	**38,534**	**698**	**12,147**

(continued)

TABLE A-2. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT OILS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lb-eq/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Metals								
Aluminum	7,302	19,026	2,714	8,723	4,589	10,303	294	659
Barium	98	2,812	42	753	56	2,059	0	4
Boron	18,093	499,527	14,479	371,923	3,615	127,604	651	22,969
Cobalt	306	15,044	306	15,044	0	0	0	0
Germanium	3,073	37,014	3,073	37,014	0	0	0	0
Iron	8,321	98,369	4,275	31,055	4,046	67,314	23	377
Magnesium	19,339	468,187	11,369	342,582	7,970	125,605	0	0
Manganese	406	14,529	406	10,555	0	3,974	0	278
Molybdenum	683	15,705	291	8,516	392	7,188	78	1,438
Phosphorus	3,381	63,752	3,381	42,197	0	21,554	0	0
Silicon	2,333	87,629	2,333	62,160	0	25,469	0	0
Strontium	17	2,650	17	1,612	0	1,038	0	0
Sulfur	22,274	3,335,305	22,274	3,335,305	0	0	0	0
Tin	22	1,475	19	395	3	1,080	1	324
Titanium	9	63	4	14	5	50	0	1
Total Non-conventional Metals	**85,655**	**4,661,087**	**64,980**	**4,267,848**	**20,675**	**393,239**	**1,047**	**26,050**
Classical Parameters								
Chemical Oxygen Demand (COD)	8,008,834	82,469,852	4,032,459	31,672,499	3,976,375	50,797,354	0	0
Total Dissolved Solids	1,180,709	81,568,044	1,180,709	81,568,044	0	0	0	0
Total Organic Carbon (TOC)	1,662,243	25,025,482	1,097,930	13,130,781	564,313	11,894,701	0	0
Total Cyanide	3	135	3	78	0	57	0	0

[a]All loadings and reductions take into account the removals by POTWs for indirect discharges.
HEM - Hexane extractable material

TABLE A-3. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT ORGANICS SUBCATEGORY[a]

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lbs/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Conventionals								
Biochemical Oxygen Demand 5-Day (BOD_5)	5,366	**	5,366	**	0	3,429,305	0	0
Oil and Grease (measured as HEM)	23,062	**	23,062	**	0	29,974	0	0
Total Suspended Solids (TSS)	5,888	**	5,888	**	0	170,673	0	0
Priority Organics								
1,1-Dichloroethane	1	0	1	0	0	0	0	0
1,1-Dichloroethene	1	498	1	468	0	100	0	5
1,1,1-Trichloroethane	1	183	1	159	0	251	0	0
1,1,2-Trichloroethane	2	810	2	719	0	206	0	1
1,2-Dichloroethane	1	315	1	224	0	823	0	1
Benzene	1	121	1	95	0	484	0	0
Chloroform	9	741	9	538	0	766	0	0
Methylene Chloride	27	262,781	27	105,692	0	343,588	0	66
Pentachlorophenol	103	1,782	103	851	0	1,081	0	410
Phenol	47	95	47	41	0	1,136	0	2
Tetrachloroethylene	15	337	15	275	0	397	0	1
Toluene	1	8,377	1	3,387	0	130,626	0	28
Trichloroethylene	9	374	9	269	0	801	0	1
Vinyl Chloride	1	112	1	104	0	119	0	1
Total Priority Organics	**221**	**276,525**	**221**	**112,824**	**0**	**480,379**	**0**	**516**

(continued)

TABLE A-3. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT ORGANICS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lbs/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Organics								
1,1,1,2-Tetrachloroethane	1	769	1	712	0	126	0	1
1,2-Dibromoethane	1	1,927	1	1,515	0	496	0	18,125
1,2,3-Trichloropropane	1	1,577	1	1,482	0	99	0	0
2-Butanone	115	1,013	115	662	0	10,349	0	0
2-Propanone	269	362,772	269	167,970	0	1,198,783	0	1
2,3-Dichloroaniline	3	243	3	106	0	232	0	1
2,3,4,6-Tetrachlorophenol	82	663	82	345	0	475	0	17
2,4,5-Trichlorophenol	13	292	13	132	0	222	0	4
2,4,6-Trichlorophenol	11	0	11	0	0	0	0	0
3,4-Dichlorophenol	0	0	0	0	0	0	0	0
3,5-Dichlorophenol	0	0	0	0	0	0	0	0
4-Methyl-2-Pentanone	19	1,028	19	957	0	584	0	0
Acetophenone	5	21	5	9	0	261	0	0
Aniline	1	0	1	0	0	0	0	0
Benzoic Acid	42	0	42	0	0	0	0	0
Diethyl Ether	0	7,641	0	7,226	0	446	0	0
Dimethyl Sulfone	21	0	21	0	0	0	0	0
Ethylenethiourea	574	0	574	0	0	0	0	0
Hexanoic Acid	8	108	8	47	0	381	0	0
m-Xylene	1	91	1	81	0	209	0	0
n,n-Dimethylformamide	1	1	1	1	0	0	0	0
o-Cresol	24	1,021	24	426	0	1,252	0	2
p-Cresol	9	281	9	117	0	578	0	1

(continued)

TABLE A-3. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT ORGANICS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lbs/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Organics (continued)								
Pyridine	15	53	15	22	0	659	0	0
Tetrachloromethane	2	240	2	204	0	296	0	5
Trans-1,2-Dichloroethene	3	539	3	477	0	211	0	0
Total Non-conventional Organics	**1,221**	**380,279**	**1,222**	**182,492**	**0**	**1,215,660**	**0**	**18,156**
Priority Metals								
Antimony	74	46	74	46	0	0	0	0
Chromium	72	37	72	24	0	66	0	1
Copper	92	36	92	36	0	0	0	0
Nickel	186	380	186	381	0	0	0	0
Zinc	50	94	50	57	0	179	0	2
Total Priority Metals	**474**	**593**	**474**	**543**	**0**	**244**	**0**	**3**
Non-conventional Metals								
Aluminum	323	1,610	323	795	0	9,435	0	52
Barium	0	161	0	161	0	0	0	0
Boron	6,279	14,196	6,279	8,267	0	7,766	0	1,067
Calcium	0	0	0	0	0	0	0	0
Cobalt	57	0	57	0	0	0	0	0
Iodine	0	1,902	0	1,095	0	1,328	0	0
Iron	515	1,954	515	1,064	0	4,942	0	5
Lithium	1,552	3,742	1,552	3,742	0	0	0	0
Magnesium	0	0	0	0	0	0	0	0
Manganese	30	229	30	174	0	85	0	4
Molybdenum	123	346	123	290	0	69	0	11

(continued)

TABLE A-3. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE CWT ORGANICS SUBCATEGORY[a] (CONTINUED)

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lbs/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Non-conventional Metals (continued)								
Phosphorus	904	734	904	363	0	1,212	0	0
Potassium	0	0	0	0	0	0	0	0
Silicon	350	856	350	839	0	23	0	0
Sodium	0	0	0	0	0	0	0	0
Strontium	269	1,665	269	1,214	0	530	0	0
Sulfur	178,861	484,286	178,861	244,045	0	280,426	0	0
Tin	128	236	128	236	0	0	0	0
Total Non-conventional Metals	**189,392**	**511,915**	**189,392**	**262,284**	**0**	**305,816**	**0**	**1,139**
Classical Parameters								
Total Cyanide	285	**	285	**	0	191	0	62

[a]All loadings and reductions take into account the removals by POTWs for indirect discharges.
HEM - Hexane extractable material

TABLE A-4. SUMMARY OF POLLUTANT LOADINGS AND REMOVALS FOR THE ENTIRE CWT INDUSTRY[a]

Pollutant of Concern	Current Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Wastewater Pollutant Loading (lbs/yr)		Post-Compliance Pollutant Reductions (lbs/yr)		Post-Compliance Pollutant Pound-Equivalent Removals (lbs/yr)	
	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges	Direct Discharges	Indirect Discharges
Conventionals	11,727,110	16,058,924	2,095,183	4,816,339	9,631,928	14,872,538	0	0
Total Priority Organics	3,867	326,659	1,784	120,281	2,083	523,056	89	554
Total Non-conventional Organics	29,690	919,359	21,480	278,437	8,210	1,658,795	3,124	21,266
Total Priority Metals	656,421	98,822	18,709	15,083	637,712	83,933	284,186	23,309
Total Non-conventional Metals	210,021,211	199,375,310	124,000,744	122,240,614	86,020,467	77,190,881	95,298	53,540
Total Classical Parameters (includes Total Cyanide)	244,724,315	392,049,288	170,777,844	285,800,165	73,947,785	106,257,326	180,510	11,283

[a]All loadings and reductions take into account the removals by POTWs for indirect discharges.
HEM - Hexane extractable material

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Conventionals						
Biochemical Oxygen Demand 5-Day (BOD_5)	0	0	0	0	0	0
Oil and Grease (measured as HEM)	0	0	0	0	0	0
Total Suspended Solids (TSS)	0	0	0	0	0	0
Total Conventionals	**0**	**0**	**0**	**0**	**0**	**0**
Priority Organics						
1,1,1-Trichloroethane	1	0	0	1	0	0
1,1-Dichloroethane	0	0	0	0	0	0
1,1-Dichloroethene	76	30	0	3	0	5
1,1,2-Trichloroethane	0	0	0	0	0	1
1,2,4-Trichlorobenzene	0	0	0	29	0	0
1,2-Dichloroethane	0	0	0	0	0	1
1,4-Dichlorobenzene	0	0	00	49	0	0
2,4-Dimethylphenol	0	0	0	0	0	0
Acenapthene	0	0	0	1	0	0
Anthracene	0	0	0	239	0	0
Benzene	0	0	0	5	0	0
Benzo(a)anthracene	0	0	0	3,610	0	0
Bis(2-ethylhexyl) Phthalate	0	0	2	2,995	0	0
Butyl Benzyl Phthalate	0	0	1	17	0	0
Chlorobenzene	0	0	0	0	0	0
Chloroform	0	0	0	0	0	0
Chrysene	0	0	0	85	0	0
Diethyl Phthalate	0	0	0	0	0	0
Di-n-butyl Phthalate	0	0	0	1	0	0

(continued)

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year) (CONTINUED)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Priority Organics (continued)						
Ethylbenzene	0	0	0	1	0	0
Fluoranthene	0	0	0	1,676	0	0
Fluorene	0	0	0	374	0	0
Methylene Chloride	0	0	0	0	0	66
Naphthalene	0	0	0	19	0	0
Pentachlorophenol	0	0	0	0	0	410
Phenanthrene	0	0	1	142	0	0
Phenol	0	0	0	0	0	2
Pyrene	0	0	3	120	0	0
Tetrachloroethylene	0	0	0	10	0	1
Toluene	4	0	0	5	0	28
Trichloroethylene	0	0	0	0	0	1
Vinyl Chloride	0	0	0	0	0	1
Total Priority Organics	**82**	**31**	**7**	**9,380**	**0**	**516**
Non-conventional Organics						
1,1,1,2-Tetrachloroethane	0	0	0	0	0	1
1,2-Dibromoethane	0	0	0	0	0	18,125
1,2,3-Trichloropropane	0	0	0	0	0	0
1,4-Dioxane	0	0	0	0	0	0
1-Methylfluorene	0	0	0	8	0	0
1-Methylphenanthrene	0	0	0	32	0	0
2,3-Benzofluorene	0	0	0	53	0	0
2,3-Dichloroaniline	0	0	0	0	0	1
2,3,4,6-Tetrachlorophenol	0	0	0	0	0	17

(continued)

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year) (CONTINUED)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Non-conventional Organics (continued)						
2,4,5-Trichlorophenol	0	0	0	0	0	4
2,4,6-Trichlorophenol	0	0	0	0	0	0
2-Butanone	0	0	0	0	0	0
2-Methylnaphthalene	0	0	1	808	0	0
2-Phenylnaphthalene	0	0	0	45	0	0
2-Propanone	0	0	0	0	0	1
3,4-Dichlorophenol	0	0	0	0	0	0
3,5-Dichlorophenol	0	0	0	0	0	0
3,6-Dimethylphenanthrene	0	0	0	90	0	0
4-Chloro-3-methylphenol	0	0	0	27	0	0
4-Methyl-2-pentanone	0	0	0	0	0	0
Acetophenone	0	0	0	0	0	0
Alpha-terpinol	0	0	0	0	0	0
Aniline	0	0	0	0	0	0
Benzoic Acid	2	0	0	0	0	0
Benzyl Alcohol	0	0	0	5	0	0
Biphenyl	0	0	0	4	0	0
Carbazole	0	0	0	39	0	0
Carbon Disulfide	0	0	0	375	0	0
Dibenzofuran	0	0	0	6	0	0
Dibenzothiopene	0	0	0	8	0	0
Diethyl Ether	0	0	0	0	0	0
Dibromochloromethane	16	4	0	0	0	0
Dimethyl Sulfone	0	0	0	0	0	0

(continued)

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year) (CONTINUED)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Non-conventional Organics (continued)						
Diphenyl Ether	0	0	0	1	0	0
Ethylenethiourea	0	0	0	0	0	0
Hexanoic Acid	0	0	0	7	0	0
m-Xylene	0	0	0	1	0	0
n,n-Dimethylformamide	0	0	0	0	0	0
n-Decane	0	0	0	421	0	0
n-Docosane	0	0	0	0	0	0
n-Dodecane	0	0	1	25	0	0
n-Eicosane	0	0	0	15	0	0
n-Hexacosane	0	0	0	0	0	0
n-Hexadecane	0	0	6	474	0	0
n-Nitrosomorpholine	0	0	0	0	0	0
n-Octadecane	0	0	0	143	0	0
n-Tetracosane	0	0	0	0	0	0
n-Tetradecane	0	0	2	498	0	0
o+p-Xylene	0	0	0	6	0	0
o-Cresol	0	0	0	0	0	2
p-Cresol	0	0	0	0	0	1
p-Cymene	0	0	0	0	0	0
Pentamethylbenzene	0	0	0	14	0	0
Pyridine	0	0	0	0	0	0
Styrene	0	0	0	0	0	0
Tetrachloromethane	0	0	0	0	0	5
trans-1,2-Dichloroethene	0	0	0	0	0	0
Tripropyleneglycol Methyl Ether	0	0	0	0	0	0
Total Non-conventional Organics	**18**	**4**	**12**	**3,106**	**0**	**18,156**

(continued)

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year) (CONTINUED)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Priority Metals						
Antimony	102	22	0	1	0	0
Arsenic	6,697	254	0	897	0	0
Cadmium	69,751	1,133	7	76	0	0
Chromium	10,452	280	0	44	0	1
Copper	122,672	699	64	1,945	0	0
Lead	37,123	3,047	273	6,163	0	0
Mercury	9,148	825	274	610	0	0
Nickel	9,735	3,477	0	1,610	0	0
Selenium	43	16	0	4	0	0
Silver	10,844	1,307	0	0	0	0
Zinc	6,922	100	81	797	0	2
Total Priority Metals	**283,488**	**11,159**	**698**	**12,147**	**0**	**3**
Non-conventional Metals						
Aluminum	8,228	593	294	659	0	52
Barium	0	0	0	4	0	0
Beryllium	0	0	0	0	0	0
Boron	18,351	13,485	651	22,969	0	1,067
Calcium	302	362	0	0	0	0
Chloride	1,433	1,257	0	0	0	0
Cobalt	1,999	70	0	0	0	0
Fluoride	6,809	186	0	0	0	0
Germanium	0	0	0	0	0	0
Iodine	0	0	0	0	0	0
Iridium	0	0	0	0	0	0

(continued)

TABLE A-5. POST-COMPLIANCE POLLUTANT POUND-EQUIVALENT REMOVALS (lb-eq/year) (CONTINUED)

Pollutant of Concern	Metals 4		Oils 9		Organics 4	
	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)	Direct Discharges (lb-eq/yr)	Indirect Discharges (lb-eq/yr)
Non-conventional Metals (continued)						
Iron	603	35	23	377	0	5
Lithium	1,104	1,019	0	0	0	0
Magnesium	0	0	0	0	0	0
Manganese	1,088	267	0	278	0	4
Molybdenum	3,575	2,364	78	1,438	0	11
Phosphorus	0	0	0	0	0	0
Potassium	5,644	4,310	0	0	0	0
Silicon	0	0	0	0	0	0
Sodium	27	28	0	0	0	0
Strontium	0	0	0	0	0	0
Sulfur	22	12	0	0	0	0
Tin	39,389	1,757	1	324	0	0
Titanium	2,166	4	0	1	0	0
Vanadium	2,729	128	0	0	0	0
Yttrium	0	0	0	0	0	0
Zirconium	783	472	0	0	0	0
Total Non-conventional Metals	**94,251**	**26,350**	**1,047**	**26,050**	**0**	**1,139**
Classical Parameters			0	0	0	0
Ammonia as N	1,686	1,287	0	0	0	0
Chemical Oxygen Demand (COD)	0	0	0	0	0	0
Hexavalent Chromium	172,247	8,062	0	0	0	0
Total Dissolved Solids (TDS)	0	0	0	0	0	0
Total Organic Carbon (TOC)	0	0	0	0	0	0
Cyanide, Total	6,577	1,872	0	0	0	62
Total Classical Parameters	**180,510**	**11,221**	**0**	**0**	**0**	**62**